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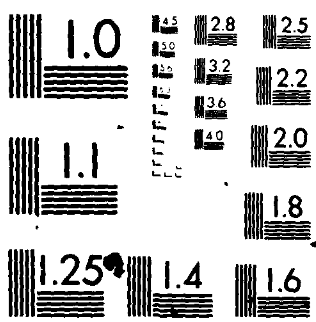

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RADIATION CORRECTIONS USED IN THE AFGWC STRATOSPHERIC ANALYSIS MODELS

BY

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SEPTEMBER 1980

UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)
AIR FORCE GLOBAL WEATHER CENTRAL
OFFUTT AFB NE 68113

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At stratospheric levels, radiosonde temperature sensors are affected not only by the ambient air temperature but also by direct short-wave solar radiation and by long-wave radiation. The short-wave radiation causes a radiosonde temperature sensor to sense a temperature warmer than the ambient air. The long-wave radiation causes the temperature sensor to measure a temperature cooler than the ambient air. This technical note describes how corrections are applied to radiosonde temperature observations to account for the effects of short-and long-wave radiation.

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PREFACE

This Technical Note describes the changes that were made on 5 August 1980 to the radiation corrections used in the Air Force Global Weather Central (AFGWC) stratospheric analysis models. This description was written for users of the AFGWC stratospheric analyses and the climatology derived from the analyses by the United States Air Force Environmental Technical Applications Center (USAFETAC).

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30 September 1980

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1. INTRODUCTION

At 12 GMT on 5 August 1980, the radiation corrections used in the AFGWC stratospheric analysis models were updated. The AFGWC stratospheric analysis models were described by Lewis, Tarbell, and Hoke (1980). Tarbell and Hoke (1979) detailed the way in which the stratospheric analysis models fit into the entire AFGWC production cycle.

Prior to 5 August 1980, the radiation corrections used were taken from Finger et al. (1965). The new radiation corrections were provided by McInturff et al. (1979). Short-wave and long-wave corrections are made to radiosonde observations (RAOBs) of temperature and the height values which are derived from the RAOB temperature. The short-wave temperature corrections made at 100 mb and higher compensate for the effects of direct solar radiation on different radiosonde temperature sensors. That is, during daylight hours at stratospheric levels, radiosondes sense temperatures warmer than the ambient air temperature because this direct solar radiation is also sensed. After short-wave corrections have been made, long-wave radiation corrections are applied at 10 mb and above (Finger et al., 1965) to increase the reported temperatures to compensate for long-wave radiational cooling of the sensor.

Section 2 describes the radiation corrections used at AFGWC prior to 5 August 1980. In Section 3, we present the new radiation correction procedure. Section 4 contains a discussion of the differences between the old and new radiation correction procedures. We present our concluding remarks in Section 5.

2. OLD RADIATION CORRECTIONS

2.1 Short-wave Corrections. Short-wave radiation corrections have been an attempt to compensate for the sensing of direct solar radiation by the radiosonde temperature sensor. The short-wave radiation corrections were a function of pressure level, solar angle, and instrument type. The pressure levels were 100, 70, 50, 30, 20, and 10 mb. The solar angle was a function of the radiosonde latitude, longitude, release time, and ascent rate, which was assumed to be 305 meters per minute. The eight instrument types for which corrections were applied are listed in Table 1.

Finger *et al.* (1965) provided the equations used to compute the solar elevation angle. For each of the eight instrument types, Table 1 contains the temperature correction to be subtracted from the reported RAOB temperature for the six mandatory levels from 100 through 10 mb and for 11 solar elevation angles ranging from -10 degrees through 90 degrees in increments of 10 degrees. For a given instrument type, solar angle, and level, the specific short-wave radiation correction can be obtained by a linear interpolation between two values in Table 1.

TABLE 1. Short-wave corrections for various radiosonde instruments used at AFGWC prior to 5 August 1980 as a function of pressure level and solar elevation angle. This table contains temperature values (°C) that are to be subtracted from the temperatures measured by the radiosonde instrument. (Source: AFGWC radiation correction program RADCOR.) A "-" means that no short-wave temperature correction was computed for that level and solar elevation angle.

		Solar Elevation Angle										
Instrument Type	Level	-10	0	10	20	30	40	50	60	70	80	90
a. U.S. Weather Bureau	100	-0.3	0.3	0.6	0.8	0.9	1.0	1.0	1.0	0.9	0.8	0.5
	70	-0.3	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.5
	50	-0.3	0.5	0.8	1.0	1.2	1.2	1.3	1.3	1.1	1.0	0.6
	30	-0.3	0.7	1.2	1.4	1.6	1.6	1.7	1.6	1.4	1.1	0.7
	20	-0.1	0.9	1.6	1.8	2.0	2.0	2.0	1.9	1.6	1.2	0.8
	10	-0.5	1.5	2.2	2.5	2.6	2.7	2.6	2.5	2.2	1.8	1.2
b. French (Metox)	100	-	-	0.8	1.2	1.6	2.0	2.3	2.6	2.4	1.7	0.9
	70	-	-	1.3	2.0	2.5	3.0	3.5	3.8	3.8	3.1	1.7
	50	-	-	1.8	2.7	3.4	4.1	4.6	5.1	5.2	4.6	2.6
	30	-	-	2.7	4.2	5.4	6.4	7.0	7.6	7.6	6.5	3.0
	20	-	-	3.6	5.7	7.2	8.2	9.0	9.6	9.5	8.3	5.5
	10	-	-	5.6	8.3	10.5	12.2	13.2	14.0	14.0	13.0	11.6

Table 1 (Continued)

Instrument Type	Level	-10	0	10	20	30	40	50	60	70	80	90
						Solar Elevation Angle						
c. Finnish (Väisälä)	100	-0.2	0.2	0.4	0.6	0.8	1.0	1.1	1.1	1.0	0.8	0.6
	70	-0.6	0.1	0.3	0.6	0.8	1.0	1.1	1.2	1.0	0.8	0.[illegible]
	50	-1.0	0.0	0.3	0.6	0.8	1.0	1.3	1.2	1.0	0.8	0.6
	30	-1.4	-0.3	0.2	0.4	0.8	1.0	1.3	1.3	1.1	0.9	0.7
	20	-1.8	-0.6	0.0	0.4	0.8	1.0	1.4	1.3	1.1	0.9	0.7
	10	-3.0	-0.6	0.0	0.5	0.9	1.1	1.4	1.3	1.2	1.0	0.8
d. Japanese	100	-	-	1.2	1.4	1.4	1.3	1.1	0.9	0.7	-	-
	70	-	-	1.8	2.1	2.0	1.7	1.4	1.1	0.7	-	-
	50	-	-	2.4	2.8	2.6	2.2	1.8	1.3	0.6	-	-
	30	-	-	3.0	3.6	3.3	2.9	2.4	1.8	1.1	-	-
	20	-	-	3.3	3.9	3.6	3.0	2.3	1.6	0.5	-	-
	10	-	-	3.8	4.7	4.0	3.0	2.0	0.7	-0.8	-	-
e. East German (Freiberg)	100	-	-	0.8	1.1	1.4	1.8	2.0	2.3	-	-	-
	70	-	-	1.2	1.5	1.8	2.2	2.4	2.6	-	-	-
	50	-	-	1.6	1.9	2.2	2.6	2.8	3.0	-	-	-
	30	-	-	2.4	3.4	4.2	2.8	5.2	5.4	-	-	-
	20	-	-	3.0	4.5	5.5	6.1	6.5	6.7	-	-	-
	10	-	-	5.8	6.8	7.6	8.0	8.1	8.2	-	-	-
f. British (Kew)	100	-	-	0.6	1.0	1.0	0.6	0.6	0.6	-0.4	-1.3	-
	70	-	-	0.6	1.1	1.0	0.6	0.8	0.8	-0.1	-1.1	-
	50	-	-	0.6	1.2	1.0	0.6	1.0	1.1	-0.2	-0.8	-
	30	-	-	1.6	2.0	1.6	1.0	1.4	1.4	-0.8	-3.4	-
	20	-	1.5	2.6	2.8	3.0	2.4	2.4	2.0	0.0	-3.6	-
	10	-	4.0	5.2	5.4	5.0	4.4	4.4	4.6	2.8	0.7	-
g. Chinese	100	-	-	-	-	0.0	1.0	3.0	3.0	3.0	0.0	
	70	-	-	-	-	1.0	1.5	2.5	2.5	2.5	0.5	
	50	-	-	-	-	2.0	2.0	2.0	2.0	2.0	1.0	
	30	-	-	-	-	2.0	2.0	2.0	2.0	2.0	1.0	
	20	-	-	-	-	2.0	2.0	2.0	2.0	2.0	1.0	
	10	-	-	-	-	2.0	2.0	2.0	2.0	2.0	1.0	
h. USSR	100	-0.6	0.2	0.8	0.9	1.0	1.0	1.0	1.0	0.8	-	-
	70	-0.4	0.4	1.0	1.1	1.3	1.4	1.5	1.4	1.2	-	-
	50	-0.6	0.6	1.2	1.4	1.6	1.8	2.0	1.9	1.7	-	-
	30	-0.2	1.0	1.4	1.8	2.0	2.3	2.5	2.4	2.2	-	-
	20	-0.2	1.4	2.2	2.5	2.7	2.9	3.0	2.8	2.6	-	-
	10	0.2	2.4	3.2	3.7	4.0	4.3	4.4	4.1	3.9	-	

Given the corrected temperatures at 100 through 10 mb, the 100- through 10-mb heights were corrected using the hypsometric equation:

$$z_2 = z_1 + \frac{R}{g} \frac{(T_1 + T_2)}{2} \ln \frac{p_1}{p_2} \tag{1}$$

where z = height of a level (m),

p = pressure of a level (mb),

T = corrected absolute temperature of a level (K),

g = the acceleration of gravity (9.8 m s^{-2}),

R = the gas constant for dry air (287 joule $g^{-1}K^{-1}$), and the subscripts 1 and 2 refer to the lower and upper levels, respectively. Note that the 150-mb height is required to compute the corrected 100-mb height.

2.2 Long-wave Corrections. The long-wave radiation corrections were a function of temperature and height of the level. The long-wave correction was applied only at 10 mb, only during daylight hours, and only to the instrument types in Table 1. The short-wave correction had already been applied to the 10-mb temperature and height prior to the long-wave correction. The long-wave temperature correction takes the form

$$T'_{10} = 1.089\ T_{10} + 7.25^{\circ}C \tag{2}$$

where T_{10} is the 10-mb temperature ($^{\circ}C$) corrected for short-wave radiation and T'_{10} is the 10-mb temperature ($^{\circ}C$) corrected for long-wave (and short-wave) radiation. The long-wave correction was applied to the 10-mb height value using the hypsometric equation.

NMC has used a long-wave temperature correction slightly different from (2). Their corrections varied from 1.1°C less at -30°C to 0.2°C less at -70°C. NMC has used an expression analogous to (2) for the long-wave height correction rather than the hypsometric equation. The long-wave height corrections computed from the hypsometric equation are almost identical to those used by NMC. Like AFGWC, NMC applied the long-wave corrections only during daylight hours and only to the instrument types in Table 1.

3. NEW RADIATION CORRECTIONS

3.1 Short-wave Corrections. The new short-wave radiation corrections are functions of the same parameters as before: level, solar angle, and instrument type. However, new 70-mb corrections were not given by McInturff *et al.* (1979) and were therefore obtained using a logarithmic interpolation in pressure between the 100-mb and 50-mb levels. Also, corrections for twelve instruments types are now available. Table 2 (taken from McInturff *et al.*, 1979) contains the temperature corrections to be subtracted from the reported RAOB temperature. These values are given for the six mandatory levels from 100 through 10 mb and for 10 solar elevation angles ranging from -5 degrees though 85 degrees in increments of 10 degrees. McInturff *et al.* (1979) presented the equations used to compute the solar angle. Corrections were not given for a solar elevation angle of 90 degrees because the radiosonde temperature sensor is normally shaded by the radiosonde balloon.

The height corrections to be subtracted from the calculated RAOB heights are also presented in Table 2. Recall that prior to 5 August 1980, the corrected heights were computed using corrected temperatures and the hypsometric equation.

Table 2. Short-wave temperature and height corrections for various radiosonde instruments used since 5 August 1980 at AFGWC as a function of pressure level and solar elevation angle. The atmospheric variable (Vrbl) column is either T for temperature (°C) or H for height (m). These values are subtracted from the reported temperatures and heights, respectively. The 70-mb values were interpolated from the 100-mb and 50-mb values. (Source: McInturff *et al.*, 1979.) A "-" means that no short-wave correction was computer for that level and solar elevation angle.

			Solar Elevation Angle									
Instrument Type	Level	Vrbl	-5	5	15	25	35	45	55	65	75	85
a. U.S. NOAA	100	T	0.1	0.5	0.7	0.7	0.8	1.2	1.6	1.0	-	-
(12 GMT)		H	-8	1	12	17	23	29	70	32	-	-
	70	T	0.0	0.5	0.7	0.8	1.0	1.3	1.3	1.3	-	
		H	-9	3	15	24	30	40	126	50	-	
	50	T	0.0	0.5	0.7	0.9	1.1	1.4	1.0	1.5	-	
		H	-9	5	18	31	36	50	181	77	-	
	30	T	-0.1	0.6	1.0	1.1	1.4	1.3	2.2	-0.4	-	-
		H	-14	7	25	34	44	59	107	47	-	-
	20	T	-0.2	0.8	1.1	1.1	1.5	1.2	1.3	-	-	-
		H	-20	4	29	39	64	59	54	-	-	-
	10	T	0.0	1.3	1.3	1.1	1.3	1.9	3.5	-	-	-
		H	-39	-7	30	44	71	102	119	-	-	-

Table 2 (Continued).

Instrument Type	Level	Vrbl	-5	5	15	25	35	45	55	65	75	85
			Solar Elevation Angle									
b. U.S. NOAA	100	T	0.2	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.2	1.0
(00 GMT)		H	15	30	38	42	40	35	34	36	34	2[illegible]
	70	T	0.4	0.9	1.1	1.2	1.2	1.1	1.1	1.2	1.1	0.9
		H	22	42	51	56	55	48	43	44	43	33
	50	T	0.5	1.1	1.3	1.4	1.4	1.2	1.1	1.3	1.0	0.9
		H	27	49	60	66	65	56	49	49	49	42
	30	T	0.9	1.6	1.8	2.1	1.9	1.4	1.4	1.0	1.6	1.2
		H	46	74	88	98	94	88	71	65	72	8[illegible]
	20	T	1.2	1.9	2.3	2.6	2.4	1.8	1.5	1.3	1.3	2.[illegible]
		H	70	100	116	132	129	107	100	95	106	9[illegible]
	10	T	1.9	2.4	2.9	3.2	2.6	2.8	2.3	2.5	1.1	3.[illegible]
		H	116	143	178	175	172	158	132	134	151	-1
c. FRENCH	100	T	-	-	0.4	0.6	0.6	0.3	0.6	0.5	-	
Mesural		H	-	-	16	19	23	27	19	7	-	
(used with-	70	T	-	-	0.7	0.7	0.7	0.6	0.7	0.9	-	
in France)		H	-	-	15	24	27	31	23	16	-	
	50	T	-	-	0.9	0.8	0.8	0.8	0.8	1.2	-	
		H	-	-	14	29	31	34	27	25	-	
	30	T	-	-	1.1	1.2	1.0	1.3	1.1	0.9	-	
		H	-	-	4	5	5	4	5	4	-	
	20	T	-	-	1.2	1.3	1.8	1.2	1.6	1.8	-	-
		H	-	-	6	7	7	7	6	6	-	-
	10	T	-	-	1.9	2.2	2.6	3.1	1.1	0.9	-	-
		H	-	-	10	12	10	10	8	14	-	-
d. Finnish	100	T	0.1	0.3	0.3	0.4	0.6	0.5	0.8	1.3	1.3	-
Väisälä		H	-2	4	7	12	18	15	30	37	26	-
	70	T	0.1	0.6	0.7	0.7	0.9	0.9	0.9	1.0	0.6	
		H	-4	8	13	19	25	23	20	36	13	
	50	T	0.1	0.8	1.0	1.0	1.2	1.2	1.0	0.8	-	
		H	-6	11	18	26	32	30	11	35	-	-
	30	T	0.1	2.0	2.4	2.2	2.0	1.5	0.4	0.1	-	-
		H	3	28	37	43	55	43	29	29	-	-
	20	T	0.1	1.9	2.4	2.0	2.0	1.6	0.4	0.1	-	
		H	0	42	65	65	74	48	38	61	-	
	10	T	2.6	3.1	4.0	1.8	3.3	1.4	2.5	-	-	-
		H	83	83	127	91	77	53	73	-	-	-

Table 2 (Continued).

Instrument Type	Level	Vrbl	-5	5	15	25	35	45	55	65	75	85
						Solar Elevation Angle						
e. Japanese 'Code Sending'	100	T	0.1	0.6	0.7	0.7	0.9	0.8	1.3	1.0	0.8	
		H	1	14	28	26	27	32	31	22	22	
	70	T	0.1	0.7	0.9	0.8	1.1	1.0	1.0	0.9	1.4	-
		H	2	19	34	32	36	41	25	29	32	-
	50	T	0.1	0.8	1.1	0.9	1.2	1.1	0.7	0.9	1.7	-
		H	3	23	39	37	44	50	19	36	42	-
	30	T	0.4	1.1	1.3	1.4	1.2	1.0	0.8	1.3	1.6	-
		H	13	37	49	48	49	62	45	54	65	
	20	T	5.0	1.4	1.4	1.4	1.3	1.0	1.4	1.4	1.2	
		H	22	53	55	66	62	83	95	71	73	
	10	T	1.5	1.9	1.3	1.2	2.2	0.4	1.7	1.0	1.3	
		H	68	91	65	74	90	71	98	102	116	
f. United Kingdom KEW Mark IIB	100	T	-	-0.2	0.1	0.3	0.2	0.0	-0.3	-0.1	-	-
		H	-	-12	-1	1	5	0	-1	4	-	-
	70	T	-	-0.6	-0.1	0.2	0.0	-0.2	-0.1	0.1	-	-
		H	-	-16	-2	2	2	-3	-6	-2	-	-
	50	T	-	-1.0	-0.3	0.1	-0.1	-0.3	0.0	0.3	-	-
		H	-	-20	-3	3	-1	-5	-9	3	-	-
	30	T	-	-0.5	-0.1	0.8	0.3	0.1	0.4	-0.1	-	-
		H	-	-31	-14	5	5	-2	-10	1	-	
	20	T	-	0.3	0.4	1.6	1.5	1.1	0.8	0.0	-	
		H	-	-39	-18	27	24	11	2	0	-	
	10	T	-	3.2	3.3	4.3	3.3	2.8	1.4	0.0	-	-
		H	-	10	36	116	56	26	34	0	-	-
g. Chinese	100	T	0.0	-0.2	0.0	0.4	0.4	0.6	-	-	-	-
		H	1	-16	-15	-13	-4	-8	-	-	-	-
	70	T	-	-	-	-	-	-	-	-	-	-
		H	-	-	-	-	-	-	-	-	-	-
	50	T	-	-	-	-	-	-	-	-	-	
		H	-	-	-	-	-	-	-	-	-	
	30	T	-	-	-	-	-	-	-	-	-	
		H	-	-	-	-	-	-	-	-	-	
	20	T	-	-	-	-	-	-	-	-	-	-
		H	-	-	-	-	-	-	-	-	-	-
	10	T	-	-	-	-	-	-	-	-	-	-
		H	-	-	-	-	-	-	-	-	-	-

Table 2 (Continued).

Instrument Type	Level	Vrbl	Solar Elevation Angle -5	5	15	25	35	45	55	65	75	85
h. USSR A-22	100	T	0.2	0.5	0.4	0.5	0.5	0.3	0.0	-	-	-
(12 GMT)		H	14	22	16	20	23	13	5	-	-	-
	70	T	0.3	0.6	0.6	0.6	0.7	0.5	0.2	-	-	-
		H	17	26	25	26	27	15	7	-	-	-
	50	T	0.3	0.6	0.7	0.7	0.9	0.6	0.4	-	-	-
		H	20	30	33	32	31	16	8	-	-	-
	30	T	0.2	0.3	0.8	0.9	0.9	0.5	0.8	-	-	-
		H	27	39	46	45	44	18	14	-	-	-
	20	T	0.3	0.5	1.0	1.0	1.2	1.0	0.2	-	-	-
		H	42	39	63	54	62	28	-14	-	-	-
	10	T	-0.2	0.2	2.5	0.3	1.8	0.2	0.0	-	-	-
		H	18	60	121	84	80	11	0	-	-	-
i. USSR A-22	100	T	0.0	0.2	0.2	0.3	0.5	0.1	0.3	-	-	-
(00 GMT)		H	-6	-1	1	2	8	-3	-8	-	-	-
	70	T	-0.1	0.3	0.4	0.4	0.7	0.3	0.3	-	-	-
		H	-7	5	3	8	14	5	-3	-	-	-
	50	T	-0.1	0.3	0.5	0.5	0.8	0.5	0.3	-	-	-
		H	-7	8	5	11	17	11	0	-	-	-
	30	T	-0.2	0.4	0.6	0.5	0.7	0.6	0.4	0.3	-	-
		H	-9	11	13	20	19	16	5	-10	-	-
	20	T	-0.1	0.6	0.9	0.9	1.1	1.2	0.9	0.0	-	-
		H	-10	18	25	22	33	32	14	-11	-	-
	10	T	0.1	0.9	1.9	2.8	0.5	2.3	2.4	-0.6	-	-
		H	-16	18	51	56	48	38	57	0	-	-
j. Australian	100	T	-	-	0.6	0.8	0.7	0.9	1.0	1.1	1.0	0.8
(Diamond		H	-	-	17	19	19	24	25	32	35	-
Hinman)	70	T	-	-	0.8	0.9	0.9	1.1	1.1	1.3	1.2	0.[illegible]
		H	-	-	28	34	26	34	36	40	20	-
	50	T	-	-	0.9	1.0	1.1	1.3	1.1	1.4	1.4	-
		H	-	-	36	44	31	41	44	48	10	-
	30	T	-	-	0.8	1.7	1.7	1.7	1.8	1.4	2.4	-
		H	-	-	55	52	52	59	61	67	48	[illegible]
	20	T	-	-	1.8	1.7	1.6	2.8	2.2	1.7	1.4	
		H	-	-	-	-	168	100	78	100	-	-
	10	T	-	-	-	-	-	-	-	-	-	-
		H	-	-	-	-	-	-	-	-	-	-

Table 2 (Continued).

Instrument Type	Level	Vrbl	Solar Elevation Angle -5	5	15	25	35	45	55	65	75	85
k. Canadian Sangamo	100	T	0.1	0.6	0.7	0.7	0.9	0.8	1.3	1.0	0.8	-
		H	1	14	28	26	27	32	31	22	22	-
	70	T	0.1	0.7	0.9	0.8	1.1	1.0	0.9	0.9	1.4	-
		H	2	20	35	33	38	43	24	30	34	-
	50	T	0.1	0.8	1.1	0.9	1.2	1.1	0.7	0.9	1.7	-
		H	3	23	39	37	44	50	19	36	42	-
	30	T	0.4	1.1	1.3	1.4	1.2	1.0	0.8	1.3	1.6	-
		H	13	37	49	48	49	62	45	54	65	-
	20	T	0.5	1.4	1.4	1.4	1.3	1.0	1.4	1.4	1.2	-
		H	22	53	55	66	62	83	95	71	63	-
	10	T	1.5	1.9	1.3	1.2	2.2	0.4	1.7	1.0	1.3	-
		H	68	91	65	74	90	71	98	102	116	-
l. U.S. AN/AMT4	100	T	-0.1	0.4	0.8	0.8	0.9	0.9	1.0	0.8	0.9	-
		H	-11	6	22	26	28	36	33	33	30	-
	70	T	0.1	0.6	0.8	1.0	1.0	1.0	1.2	1.2	0.3	-
		H	-15	13	28	36	36	44	44	46	12	-
	50	T	0.2	0.8	0.8	1.1	1.1	1.1	1.4	1.5	-	-
		H	-18	17	31	43	42	49	52	55	-	-
	30	T	0.8	1.2	1.7	1.4	1.8	1.5	1.7	1.8	-	-
		H	36	48	50	56	68	67	77	43	-	-
	20	T	-	1.7	1.8	1.8	1.6	1.7	1.7	1.6	1.2	-
		H	-	78	69	76	91	90	97	72	53	-
	10	T	1.5	1.4	2.9	1.7	2.0	2.5	2.7	2.3	1.9	-
		H	107	69	109	109	119	136	144	128	89	-
m. West Germany (Graw M-60)	100	T	-	-	0.4	0.5	0.3	0.4	0.3	0.6	-	-
		H	-	-	5	12	11	13	12	17	-	-
	70	T	-	-	0.5	0.5	0.5	0.3	0.3	0.6	-	-
		H	-	-	8	14	12	14	15	19	-	-
	50	T	-	-	0.6	0.5	0.6	0.2	0.4	0.5	-	-
		H	-	-	11	16	13	14	18	21	-	-
	30	T	-	0.9	0.6	0.6	0.8	0.1	0.0	-	-	-
		H	-	17	17	23	23	11	15	-	-	-
	20	T	-	1.0	0.5	0.6	0.6	-0.1	0.4	-	-	-
		H	-	44	23	27	25	13	19	-	-	-
	10	T	-	-	0.7	0.3	0.7	-0.2	-	-	-	-
		H			28	38	35	10	5	-	-	-

Table 2 (Continued).

Instrument Type	Level	Vrbl	Solar Elevation Angle -5	5	15	25	35	45	55	65	75	85
n. French	100	T	-	-	-	3.7	2.5	2.4	2.7	2.3	1.2	-
Mesural		H	-	-	-	123	105	60	81	54	30	-
(used out-	70	T	-	-	-	4.9	3.4	3.3	1.5	2.5	1.8	-
side of		H	-	-	-	166	61	41	88	70	34	-
France)	50	T	-	-	-	6.2	4.2	4.3	0.4	3.7	2.4	-
		H	-	-	-	288	16	22	96	86	38	
	30	T	-	-	-	7.6	6.6	5.1	5.1	5.3	-	
		H	-	-	-	279	229	323	220	102	-	-
	20	T	-	-	-	11.4	8.8	8.5	9.3	5.0	-	-
		H	-	-	-	510	333	407	314	212	-	-
	10	T	-	-	-	-	-	-	-	-	-	-
		H	-	-	-	-	-	-	-	-	-	-

3.2 Long-wave Corrections. We now compute the long-wave radiation corrections for temperature using the same equation as NMC. That is, long-wave temperature correction is given by

$$T'_{10} = 1.0625 \quad T_{10} \quad +5.09^{\circ}C \qquad (3)$$

where T_{10} and T'_{10} have the same meaning as in (2). The long-wave height correction is computed using the hypsometric equation. However, the long-wave corrections are now applied to all 10-mb observations, day and night. Prior to 5 August 1980, the long-wave corrections were applied only to the daylight observations of the instruments listed in Table 1. Note that the short-wave height and temperature corrections were applied prior to the long-wave correction. According to Mr. James D. Laver, Climate Analysis Center, NMC, the NMC has not updated their short-wave radiation corrections to those given by McInturff et al. (1979). Also, NMC still applies the long-wave corrections only for daylight observations and certain instrument types. NMC plans to update their correction procedure in the near future.

4. DIFFERENCES BETWEEN OLD AND NEW CORRECTIONS

4.1 Old Versus New Short-wave Temperature Corrections. Table 3 contains the differences between the short-wave temperature correction for the radiosonde instruments common to both Tables 1 and 2. A negative difference means the new corrected temperatures will be warmer than the temperatures corrected using the old method (Table 1). A positive difference implies cooler corrected temperatures now than before. Since more instruments are covered by the new radiation corrections (Table 2), not all instrument types can be compared with the old correction values.

Tables 3a and 3b contain the differences between the U.S. NOAA instrument at 12 GMT and 00 GMT, respectively, and the older U.S. Weather Bureau radiosonde. The differences are small and are generally less than 0.5 degree. However, at and above 30 mb for the 12 GMT table, the differences are as large as 2.4°C. The new short-wave radiation corrections are generally smaller than the old; that is, the new corrected temperatures are generally warmer than before.

TABLE 3. Differences between old and new short-wave temperature corrections. For the radiosonde instruments common to Tables 1 and 2, the differences (new minus old) deg are given (°C). A "-" means that no short-wave correction was available either in Table 1 or Table 2.

		Solar Elevation Angle									
New and Old Instrument Types	Level (mb)	-5	5	15	25	35	45	55	65	75	85
a. U.S. NOAA (12 GMT) minus USWB	100	0.1	0.1	0.0	-0.2	-0.2	0.2	0.6	0.1	-0.9	-0.7
	70	-0.1	-0.1	-0.1	-0.2	0.0	0.3	0.3	0.3	-0.9	-0.7
	50	-0.1	-0.2	-0.2	-0.2	-0.1	0.2	-0.3	-0.2	-1.1	-0.8
	30	-0.3	-0.4	-0.3	-0.4	-0.2	-0.4	0.6	-1.9	-1.3	-0.9
	20	-0.6	-0.5	-0.5	-0.8	-0.5	-0.8	-0.7	-1.8	-1.4	-1.0
	10	-0.5	-0.6	-1.1	-1.6	-1.4	-0.8	1.1	-2.4	-2.0	-1.5
b. U.S. NOAA (00 GMT) minus USWB	100	0.2	0.3	0.2	0.2	0.1	0.0	0.0	0.1	0.4	0.4
	70	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.[illegible]
	50	0.4	0.5	0.4	0.3	0.2	-0.1	-0.2	0.1	-0.1	0.[illegible]
	30	0.7	0.7	0.5	0.6	0.3	-0.3	-0.3	-0.5	0.4	0.[illegible]
	20	0.8	0.7	0.6	0.7	0.4	-0.2	-0.5	-0.5	-0.1	1.[illegible]
	10	1.4	0.6	0.6	0.7	-0.1	0.2	0.3	0.2	-0.9	1.7

Table 3 (Continued)

New and Old Instrument Types	Level (mb)	Solar Elevation Angle -5	5	15	25	35	45	55	65	75	85
c. Finnish Väisälä, new minus old	100	0.1	0.0	-0.2	-0.3	-0.3	-0.6	-0.3	0.3	0.4	-0.[illegible]
	70	0.4	0.4	0.3	0.0	0.9	-0.2	-0.3	-0.1	-0.3	-0.[illegible]
	50	0.6	0.7	0.6	0.3	0.3	0.1	-0.3	-0.3	-0.9	-0.7
	30	1.0	2.0	2.1	1.6	1.1	0.4	-0.9	-1.1	-1.0	-0.8
	20	1.3	2.2	2.2	1.4	1.1	0.4	-1.0	-1.1	-1.0	-0.8
	10	4.4	3.4	3.8	1.1	2.3	0.2	1.2	-1.2	-1.1	-0.9
d. French Mesural (metropolitan minus French Metox)	100	-	-0.4	-0.6	-0.8	-1.2	-1.9	-1.9	-2.0	-2.0	-1.3
	70	-	-0.7	-1.0	-1.6	-2.1	-2.7	-3.0	-2.9	-3.5	-2.4
	50	-	-0.9	-1.4	-2.3	-2.6	-3.6	-4.1	-4.0	-4.9	-3.6
	30	-	-1.4	-2.4	-3.6	-4.9	-5.4	-6.2	-6.5	-7.1	-0.8
	20	-	-1.8	-3.5	-5.2	-5.7	-7.4	-7.7	-7.8	-8.9	-6.9
	10	-	-2.8	-5.1	-7.2	-8.8	-9.6	-12.5	-13.1	-13.5	-12.3
e. Japanese "code sending" types, new minus old	100	0.1	0.0	-0.6	-0.7	-0.4	-0.4	0.3	0.2	0.5	-
	70	0.1	-0.2	-1.0	-1.2	-0.7	-0.5	-0.2	0.1	1.1	
	50	0.1	-0.4	-1.5	-1.8	-1.2	-0.9	-0.8	-0.1	1.4	
	30	0.4	-0.4	-2.0	-2.0	-1.9	-1.7	-1.3	-0.2	1.1	
	20	5.0	-0.2	-2.2	-2.3	-2.0	-1.6	-1.6	0.3	1.0	-
	10	1.5	0.0	-2.9	-3.1	-1.3	-2.1	0.4	1.1	1.7	-
f. United Kingdom: Kew Mark IIB minus Kew	100	-	-0.5	-0.7	-0.7	-0.6	-0.6	-0.9	-0.3	0.7	0.7
	70	-	-0.9	-0.9	-0.8	-0.8	-0.9	-0.9	-0.3	0.6	0.5
	50	-	-1.3	-1.2	-1.0	-0.9	-1.1	-1.0	-0.3	0.3	0.[illegible]
	30	-	-1.3	-1.9	-1.0	-1.0	-1.1	-1.0	-0.5	2.1	1.[illegible]
	20	-0.7	-1.8	-2.3	-1.3	-1.2	-1.3	-1.4	-1.0	1.8	1.[illegible]
	10	-2.0	-1.2	-2.0	-0.9	-1.3	-1.6	-2.9	-3.7	-1.7	-0.[illegible]
g. USSR A22 (00 GMT) minus older model	100	0.2	-0.3	-0.6	-0.6	-0.5	-0.9	-0.9	-0.7	-0.4	
	70	-0.1	-0.4	-0.6	-0.8	-0.6	-1.1	-1.1	-1.3	-0.6	
	50	-0.1	-0.6	-0.8	-1.0	-0.9	-1.4	-1.6	-1.8	-0.9	
	30	-0.6	-0.8	-1.0	-1.4	-1.4	-1.8	-2.0	-2.0	-1.1	
	20	-0.7	-1.2	-1.4	-1.7	-1.7	-1.7	-2.0	-2.7	-1.3	-
	10	-1.4	-1.9	-1.6	-1.0	-3.6	-2.0	-1.8	-4.6	-2.0	-
h. USSR A22 (12 GMT) minus older model	100	-0.4	0.0	-0.4	-0.4	-0.5	-0.7	-1.0	-0.9	-0.[illegible]	-
	70	0.3	-0.1	-0.4	-0.6	-0.6	-0.9	-1.2	-1.3	-0.6	-
	50	0.3	-0.3	-0.6	-0.8	-0.8	-1.3	-1.5	-1.8	-0.9	-
	30	-0.2	-0.9	-0.8	-1.0	-1.1	-1.9	-1.6	-2.3	-1.1	-
	20	-0.3	-1.3	-1.3	-1.6	-1.6	-1.9	-2.7	-2.7	-1.3	-
	10	-1.5	-2.6	-1.0	-3.5	-2.3	-4.1	-4.2	-4.0	-2.0	

Table 3c contains the difference for the Finnish radiosonde instrument. The new radiation corrections are usually larger, especially for solar angles less than 55 degrees. Therefore, the new corrected temperatures are usually cooler than the previous corrected temperatures.

Table 3d contains the differences between the French Mesural instrument used within France and the older French Metox instrument. The new corrections are smaller than the old ones by about 1°C at 100 mb to more than 13°C at 10 mb and high solar angles. The new corrected temperatures over France are considerably warmer than before.

Table 3e contains the differences for the old and new Japanese radiosonde instruments. The new short-wave corrections are generally smaller. Thus new corrected temperatures are warmer, being 3°C warmer at 10 mb and at a 25-degree solar elevation angle.

The old and new United Kingdom instruments are compared in Table 3f. The new corrections are on the order of 1°C smaller so that the new corrected temperatures are warmer. The new temperatures are almost 4°C warmer at 10 mb and high solar elevation angles.

Tables 3g and 3h contain the differences between the USSR A22 instruments at 00 GMT and 12 GMT, respectively, and the previous USSR instrument. The new corrections are generally smaller with slightly smaller corrections for the 00 GMT case than the 12 GMT case. The new corrected temperatures are about 0.5 to 2.0°C warmer.

In summary, the new corrected temperatures for the radiosonde instruments that could be directly compared are slightly warmer on the average. The only large differences were for one of the French instruments, but that instrument is only used over a limited area (McInturff et al., 1979).

4.2 Other Short-wave Temperature Corrections. There are radiosonde instruments in Table 1 or Table 2 which are not in both tables and therefore no direct comparison was possible. The East German instrument is no longer used. For the Chinese instrument, there are now no corrections above 100 mb. As a result analyses above 100 mb over daylight China appear about 2°C warmer than before.

The radiosonde instrument types not considered before but available in Table 2 are: West German, Australian, Canadian, and U.S. AN/AMT 4. Therefore, the new corrected temperatures over West Germany are up to 1°C cooler, over Australia are 0.5 to 2.8°C cooler, over Canada are 0.6 to 2.2°C cooler, and over the numerous scattered locations where the U.S.

AN/AMT 4 is used are 0.4 to 2.9°C cooler. McInturff et al. (1979) provided a table that shows the locations at which the various radiosonde instrument types are used. They also stated that the new short-wave corrections (contained in Table 2) cover at least 95 percent of the radiosondes in use at that time.

4.3 Long-wave Temperature Corrections. The magnitude of the long-wave temperature corrections has decreased slightly. These corrections changed from 1.0°C to 0.8°C when the reported temperature is -70°C and from 4.3°C to 3.2°C when the reported temperature is -30°C. However, prior to 5 August 1980, the long-wave correction was not applied to observations made during darkness. The long-wave corrections are now applied to all reported temperatures for all radiosonde types. Therefore, the 10-mb temperatures observed during darkness will now be 1 to 3°C warmer than before. Finger and McInturff (1968) reported that the true diurnal temperature range in the stratosphere at mid-latitudes was 1°C at 10 mb and 0.5°C at 30 mb. The results of application of the long-wave radiation corrections to all reported 10-mb temperatures already corrected for short-wave radiation is consistent with their findings.

4.4 Height Corrections. The difference between the old and new height corrections is related to two factors:

(1) The difference between the old and new temperature corrections resulting from new correction tables and changes in temperature correction schemes.

(2) The fact that height corrections were previously computed using the hypsometric equation and short-wave height corrections are now derived from a table.

The difference in height corrections for a given level thus depends on several factors. Because of the large number of factors that influence the difference between the old and new height corrections and because stratospheric temperatures are relatively more important, specific differences between the old and new height corrections were not computed.

However, a difference has been observed when comparing a height analysis made use the old method to a height analysis made with the new method. Heights on the new analysis are higher. We attribute this difference to two factors:

1. The new corrected temperatures are generally warmer and thus thicknesses should be greater.

2. The previous use of the hypsometric equation usually lowered pressure heights more than the table corrections.

5. CONCLUDING REMARKS

Finger and McInturff (1968) stated that short-wave and long-wave radiation corrections were an attempt to achieve compatibility among radiosonde observations. These corrections combine all unexplained variability in the observations. They reported that differences in radiosonde observations can arise for at least the following reasons:

a. Differences between individual sondes or pieces of ground equipment;

b. Differences in station procedures even for stations using the same type of equipment;

c. Day-to-day changes in the albedo of the earth and clouds;

d. Synoptic changes; and

e. True diurnal temperature changes.

Finger and McInturff (1968) also pointed out that, although the radiation corrections help achieve compatibility, they do not ensure accuracy. That is, short and long-wave radiation corrections should be used but there can be no guarantee that an individual report is indeed accurate.

The use of new shortand long-wave radiation corrections in the stratosphere will affect the stratospheric analyses to some extent. Since USAFETAC uses these analyses to construct a climatology of the stratosphere, the climatology will also be affected. This Technical Note is an attempt to quantify the differences in the radiosonde temperatures used in the stratospheric analyses that result from the change to the new radiation corrections provided by McInturff et al. (1979).

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